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For: DISC WITH TEMPORARY DEFECT MANAGEMENT AREA, AND DISC DEFECT  
MANAGEMENT METHOD AND APPRATUS THEREFOR

**SUBMISSION OF VERIFIED TRANSLATION OF KOREAN PATENT APPLICATIONS**

Commissioner for Patents  
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Sir:

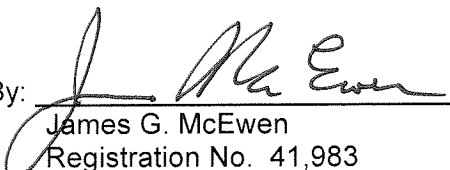
In accordance with the provisions of 37 C.F.R. § 1.78, the applicants submit herewith a translation of the above-referenced Korean patent applications 2003-2091, 2003-2092 and 2003-12867 and their accompanying certificates of translation from the translator.

If there are any additional fees associated with filing of this Submission, please charge the same to our Deposit Account No. 503333.

Respectfully submitted,

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CERTIFICATION OF TRANSLATION

I, Eun-Sook Lee, an employee of Y.P.LEE, MOCK & PARTNERS of Koryo Bldg., 1575-1 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statement in the English language in the attached translation of Korean Patent Application No. 10-2003-0002091 consisting of 47 pages have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 12th day of July 2007

Lee.S.L.

## ABSTRACT

[Abstract of the Disclosure]

5        Provided are a defect management method using a temporary defect  
management area and a temporary finalized defect management area, and an  
apparatus and disc therefor. The write once disc is a disc with at least one record  
layer on which a lead-in area, a data area, and a lead-out area are sequentially  
arranged, and includes a defect management area formed on at least one of the lead-in  
10    area and the lead-out area; a temporary defect management area formed on at least  
one of the lead-in area and the lead-out area; and a temporary finalized defect  
management area formed on at least one of the lead-in area and the lead-out area,  
wherein the temporary defect management area is an area in which temporary defect  
information indicating only information regarding defects generated during the  
15    corresponding recording operation, and temporary defect management information  
indicating information for managing the temporary defect information are recorded, the  
temporary finalized defect management area is an area in which temporary finalized  
defect management area including at least one part of the temporary defect information  
recorded in the temporary defect management area, and temporary finalized defect  
20    management information indicating information for managing the temporary finalized  
defect information are recorded, and the defect management area is an area in which  
the temporary defect information and the temporary defect management information are  
respectively recorded as defect information and defect management information when  
finalizing. Accordingly, it is possible to perform disc defect management on a write  
once disc while effectively using a defect management area of the disc.

25

[Representative Drawing]

FIG. 4

## SPECIFICATION

[Title of the Invention]

5        APPARATUS AND METHOD FOR MANAGING DEFECT USING TEMPORARY  
DMA AND TEMPORARY FDMA AND A DISC THEREOF

[Brief Description of the Drawings]

10        The above and/or other aspects and advantages of the invention will become  
apparent from the following description of the embodiments, taken in conjunction with  
the accompanying drawings in which:

FIG. 1 is a block diagram of a recording apparatus according to a preferred  
embodiment of the present invention;

15        FIG. 2 illustrates a structure of a disc according to a preferred embodiment of the  
present invention;

FIG. 3A illustrates a data structure of the disc illustrated in FIG. 2;

FIG. 3B illustrates an example of a temporary defect management area, a  
temporary finalized defect management area, and a defect management area illustrated  
in FIG. 3A;

20        FIG. 4 is a view for explaining a relationship between the temporary defect  
management area and the temporary finalized defect management area, according to  
the present invention;

FIGS. 5A and 5B illustrate a data structure of the temporary defect management  
area, according to an embodiment of the present invention;

25        FIGS. 6A and 6B illustrate a data structure of the temporary finalized defect  
management area, according to an embodiment of the present invention;

FIGS. 7A and 7B respectively illustrate data structures of temporary defect  
management information *TDDS #i* and a copy thereof;

FIG. 8 illustrates a data structure of temporary defect information *TDFL #i*

according to another embodiment of the present invention;

FIG. 9 illustrates diagrams explaining recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention;

FIG. 10 illustrate data structures of temporary defect information *TDFL #1* and  
5 *TDFL #2* recorded as illustrated in FIG. 9;

FIG. 11 illustrates a data structure of information regarding defect #*i*;

FIG. 12 is a flowchart illustrating a disc defect management method according to a preferred embodiment of the present invention; and

FIG. 13 is a flowchart illustrating a defect management method according to  
10 another embodiment of the present invention.

[Detailed Description of the Invention]

[Object of the Invention]

[Technical Field of the Invention and Related Art prior to the Invention]

15 The present invention relates to disc defect management, and more particularly, to a defect management method using a temporary defect management area and a temporary finalized defect management area, and an apparatus and disc therefor.

Disc defect management is the process of rewriting data stored in a user data area of a disc in which a defect exists to a new portion of the disc's data area, thereby  
20 compensating for data loss caused by the defect. In general, disc defect management is performed using linear replacement or slipping replacement. In linear replacement, the user data area in which a defect exists is replaced with a spare data area having no defects. In slipping replacement, the user data area with the defect is slipped and the next user data area having no defects is used.

25 Both linear replacement and slipping replacement are, however, applicable only to discs such as a DVD-RAM/RW, on which data can be repeatedly recorded and recording can be performed using a random access method. In other words, linear replacement and slipping replacement are difficult to be applied to write once discs on which recording is allowed only once. In general, the presence of defects in a disc is

detected by recording data on the disc and confirming whether or not data has been recorded correctly on the disc. However, once data is recorded on a write once disc, it is impossible to overwrite new data and manage defects therein.

After the development of a CD-R and a DVD-R, a high-density write once disc with a recording capacity of several dozen GBs was introduced. This type of disc can be used as a backup disc since it is not expensive and allows random access that enables fast reading operations. However, disc defect management is not available for write once discs. Therefore, a backup operation may be discontinued when a defective area, i.e., an area where a defect exists, is detected during the backup operation. In general, a backup operation is performed when a system is not frequently used, e.g., at night when a system manager does not operate the system. In this case, it is more likely that the backup operation will be discontinued when because a defective area of a write once disc is detected.

#### [Technical Goal of the Invention]

The present invention provides a write once disc, and a disc defect management method and apparatus applicable to the write once disc.

The present invention also provides a disc in which disc defect management can be performed even when a disc defect is detected during a recording operation, thus allowing the recording operation to be performed without interruption, and a disc defect management method and apparatus therefor.

The present invention also provides a disc in which defect information can be effectively recorded, and a disc defect management method and apparatus therefor.

#### [Structure and Operation of the Invention]

According to an aspect of the present invention, there is provided a write once disc with at least one record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, and includes a defect management area formed on at least one of the lead-in area and the lead-out area; a temporary defect management

area formed on at least one of the lead-in area and the lead-out area; and a temporary finalized defect management area formed on at least one of the lead-in area and the lead-out area, wherein the temporary defect management area is an area in which temporary defect information indicating only information regarding defects generated  
5 during the corresponding recording operation, and temporary defect management information indicating information for managing the temporary defect information are recorded, the temporary finalized defect management area is an area in which temporary finalized defect management area including at least one part of the temporary defect information recorded in the temporary defect management area, and  
10 temporary finalized defect management information indicating information for managing the temporary finalized defect information are recorded, and the defect management area is an area in which the temporary defect information and the temporary defect management information are respectively recorded as defect information and defect management information when finalizing.

15 According to another aspect of the present invention, there is provided a write once disc with a first record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, and a second record layer on which an outer area, a data area, and a lead-out area are sequentially arranged, the write once disc including a defect management area formed on at least one of the lead-in area, the lead-out area,  
20 and the outer area; a temporary defect management area formed on at least one of the lead-in area, the lead-out area, and the outer area; and a temporary finalized defect management area formed on at least one of the lead-in area, the lead-out area, and the outer area, wherein the temporary defect management area is an area in which temporary management information indicating only information regarding defects  
25 generated during the corresponding recording operation is recorded, the temporary finalized defect management area is an area in which temporary finalized management area including at least one part of the temporary management information is recorded, and the defect management area is an area in which the temporary management information recorded when finalizing and the defect information and the defect

management information obtained on the basis of the temporary finalized management information are respectively recorded.

Here, the temporary finalized management information is recorded whenever the temporary management information is recorded  $k$  times.

5        The temporary finalized management information is obtained on the basis of temporary management information recorded when a target recording time reaches, and includes temporary defect information constructing the temporary management information.

10       The temporary management information includes the temporary defect information and the temporary defect management information. The temporary defect information and the temporary defect management information are recorded several times in pairs. The temporary defect management information includes information indicating a location in which the corresponding temporary defect information is recorded.

15       According to yet another aspect of the present invention, there is provided a method of managing disc defects, the method comprising (a) recording only information regarding a defect detected in data, which is recorded in a data area of a disc during a first recording operation, as first temporary defect information in a temporary defect management area; (b) repeating (a) and (b) at least once while increasing indexes  
20       given to the recording operation and the temporary management information by 1; (c) recording temporary management information obtained on the basis of the recorded temporary management information whenever the first temporary management information is recorded  $k$  times, in a temporary finalized defect management area; (d) repeating (a) through (c) at least once; and (e) reading and writing all of recorded  
25       temporary defect management information and temporary defect information in a defect management area ( $k$  is an integer equal to or greater than 2).

Operation (e) is performed after data according to a final operation is recorded in the data area.

The temporary management information includes temporary defect information



and temporary defect management information. In operation (a), the temporary management information is sequentially recorded ahead of or behind the temporary defect information area, in such a manner that the temporary defect information and the temporary defect management information are recorded in pairs.

5 In operation (a), the temporary defect information and the temporary defect management information are recorded several times, and location information of temporary defect information corresponding to each temporary defect management information and location information of temporary defect information recorded just before the temporary defect management information are recorded in the temporary  
10 defect management information.

Operation (a) includes (a1) recording data in a predetermined unit of data; (a2) verifying the recorded data to detect a part in which a defect is found; (a3) storing defective area information indicating the part in which the defect is found, and information indicating a substitution area for substituting for the part in which the defect  
15 is found, as temporary defect information, in a memory; (a4) repeating operation (a1) through (a3) at least one time; (a5) if the recording operation is terminated, reading the information stored in the memory and recording the read information as temporary defect information in the temporary defect management area; and (a6) recording temporary defect management information for managing the temporary defect  
20 information.

Meanwhile, according to still another aspect of the present invention, there is provided a recording apparatus comprising a recording/reading unit that records data on or reads data from a disc; and a controller that controls the recording/reading unit to record information regarding a defect detected from data, which is recorded in a data  
25 area of the disc according to a recording operation, as first temporary defect information in a temporary defect management area, and to record temporary finalized management information obtained on the basis of the temporary defect management information recorded in the temporary defect management area whenever the temporary management information is recorded k times, in a temporary finalized defect

management area.

The controller controls the recording/reading unit in such a manner that the temporary defect information and the temporary defect management information constructing the temporary management information are recorded in pairs, controls the recording/reading unit so that location information of temporary defect information corresponding to the temporary management information and location information of temporary defect information recorded just before the corresponding temporary defect information are recorded, and controls the recording/reading unit so that the recording/reading unit records the temporary management information in the temporary defect management area whenever a recording operation is performed, and records defect information and defect management information obtained on the basis of the recorded temporary management information and temporary finalized information, in a defect management area, when finalizing.

Hereinafter, embodiments of the present invention will be described in detail with reference to the appended drawings.

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention. Referring to FIG. 1, the recording apparatus includes a recording/reading unit 1, a controller 2, and a memory 3. The recording/reading unit 1 records data on a disc 100, which is an information storage medium according to a preferred embodiment of the present invention, and reads back the data from the disc 100 to verify the accuracy of the recorded data. The controller 2 performs disc defect management according to the present invention. In this embodiment, the controller 2 uses a verify-after-write method in which data is recorded on the disc 100 in predetermined units of data and the accuracy of the recorded data is verified to detect if an area of the disc 100 has a defect. In other words, the controller 2 records user data on the disc 100 in units of recording operations and verifies the recorded user data to detect an area of the disc 100 in which a defect exists. Thereafter, the controller 2 creates information indicating the position of the area with the defect and stores the created information in the memory 3. When the amount of

the stored information reaches a predetermined level, the controller 2 records the stored information as temporary defect information on the disc 100.

Here, the recording operation is an operation unit determined according to a user's intention or a recording work to be performed. According to this embodiment, a recording operation indicates a process in which the disc 100 is loaded into the recording apparatus, data is recorded on the disc 100, and the disc 100 is taken out from the recording apparatus. During the recording operation, data is recorded and verified at least once; in general, data is recorded and verified several times. Defect information obtained using the verify-after-write method is temporarily stored as temporary defect information in the memory 3.

When a user presses the eject button (not shown) of the recording apparatus in order to remove the disc 100 after recording of data, the controller 2 expects the recording operation to be terminated. Next, the controller 2 reads the information from the memory 3, provides it to the recording/reading unit 1, and controls the recording/reading unit 1 to record it on the disc 100. In this case, the defect information is recorded as the temporary defect information on the disc 100 in recording operation units. Here, recoding the defect information in the recording operation units must be understood as recording information regarding a defect detected during only a corresponding recording operation unit.

When the recording of data is completed, i.e., additional data will not be recorded on the disc 100 (the disc 100 needs to be finalized), the controller 2 controls the recording/reading unit 1 to rewrite temporary defect information and temporary defect management information, which is stored in the disc 100, as defect management information to a defect management area (DMA) of the disc 100.

FIG. 2 illustrates structures of the disc 100 of FIG. 1 according to preferred embodiments of the present invention. (a) of FIG. 2 illustrates in detail a single record layer disc representation of disc 100 having a record layer L0. The disc 100 includes a lead-in area, a data area, and a lead-out area. The lead-in area is located in an inner part of the disc 100 and the lead-out area is located in an outer part of the disc 100.

The data area is present between the lead-in area and the lead-out area and divided into a user data area and a spare area.

The user data area is an area where user data is recorded, and the spare area is a replacement area for a user data area having a defect, serving to compensate for loss in the recording area due to the defect. On the assumption that defects may occur within the disc 100, it is preferable that the spare area assumes about 5% of the entire data capacity of the disc 100, so that a greater amount of data can be recorded on the disc 100.

(b) of FIG. 2 illustrates a double record layer disc representation of disc 100 having two record layers *L0* and *L1*. A lead-in area, a data area, and an outer area are sequentially formed from the inner part of the first record layer *L0* to its outer part. Also, an outer area, a data area, and a lead-out area are sequentially formed from the outer part of the second record layer *L1* to its inner part. Unlike the single record layer disc of FIG. 2A, the lead-out area is present in the inner part of the disc 100 of FIG. 2B. That is, the disc 100 of FIG. 2B has an opposite track path (OTP) in which data is recorded starting from the lead-in area of the first record layer *L0* toward its outer area and continuing from the outer area of the second record layer *L1* to its lead-out area. The spare area is allotted to each of the record layers *L0* and *L1*.

In this embodiment, the spare areas are present between the lead-in area and the user data area and between the user data area and the outer area. However, if necessary, a portion of the user data area may be used as another spare area, that is, more than one spare area may be present between the lead-in area and the lead-out area. However, the positions of the spare areas are not limited to this arrangement.

FIG. 3A illustrates a data structure of the disc 100 of FIG. 2 according to a first embodiment of the present invention. Referring to FIG. 3A, if the disc 100 is a single record layer disc, a defect management area (DMA) and a temporary DMA (TDMA) are formed in a lead-in area. Alternatively, the DMA may be included in both the lead-in area and a lead-out area, or the TDMA may also be included in the lead-out area. That is, the DMA and the TDMA may be present in at least one of the lead-in area and

the lead-out area. If the disc 100 is a double record layer disc, the DMA and the TDMA are respectively present in a lead-in area and a lead-out area located at an inner part of the disc 100. The DMA may further be included in the lead-out area and an outer area that are located at an outer part of the disc 100. Accordingly, the DMA and the TDMA  
5 are present in at least one of the lead-in area, the lead-out area, and the outer area.

In general, information relating to managing disc defects in the disc 100 is recorded in the DMA. Such information specifies or includes the structure of the disc 100 for disc defect management, whether the disc defect management is performed or not, defect information, the location of the defect information, and the position and size  
10 of a spare area. In this embodiment, because the disc 100 is a write once disc, new data is recorded after previously recorded data when the above information changes.

In general, when a disc is loaded into a recording/reading apparatus, the apparatus reads data from a lead-in area and a lead-out area of the disc to determine how to manage the disc and record data on or read data from the disc. However, if the  
15 amount of data recorded in the lead-in area and/or the lead-out area increases, a longer time is spent on preparing the recording or reproducing of data after the loading of the disc. To solve this problem, the present invention uses temporary defect management information and temporary defect information that are to be recorded in a TDMA. The TDMA is allotted to the lead-in area and/or the lead-out area of a disc, being separated  
20 from the DMA. That is, only lastly recorded defect information and defect management information, which are required to perform disc defect management, are recorded in the DMA, thereby reducing the amount of information that the recording/reading unit requires for a recording/reproducing operation.

In this embodiment, since disc defect management is performed using linear  
25 replacement, the temporary defect information includes information indicating the position of an area of the disc 100 having a defect and information indicating the position of an area of the disc 100 that is replacement for the area having the defect. More preferably, the temporary defect information further includes information indicating whether the defect occurs in a single defect block or physically continuous defect blocks.

The temporary defect management information is used to manage the temporary defect information and includes information indicating the location of the temporary defect information recorded on the disc 100. Detailed data structures of temporary defect information and temporary defect management information will be explained later.

5           In this embodiment, the temporary defect information and temporary defect management information are recorded every time when a recording operation ends. In the TDMA, information regarding a defect occurring in data recorded during a recording operation #0 and information regarding its replacement are recorded as temporary defect information #0, and information regarding a defect occurring in data recorded  
10 during a recording operation #1 and information regarding its replacement are recorded as temporary defect information #1. Further, management information for managing temporary defect information #0, #1, ... is recorded as temporary defect management information #0, #1, ... in the TDMA, the management information specifying the recording locations of the temporary defect information #0, #1, .... When additional  
15 data cannot be recorded in the data area or a user does not wish to record additional data therein, i.e., disc finalization is required, temporary defect information and temporary defect management information recorded in the TDMA are rewritten to the DMA.

          The temporary defect information and the temporary defect management  
20 information are rewritten to the DMA for the following reasons. In the case that additional data will not be recorded on the disc 100, i.e., the disc 100 needs to be finalized, only last recorded ones of the temporary defect management information and temporary defect information, which have been updated several times, are again recorded in the DMA. Thus, the recording/reading unit 1 can fast read defect  
25 management information from the disc 100 just by reading the last recorded defect management information, thereby enabling fast initializing of the disc 100. Further, recording of the temporary defect information and temporary defect management information in the DMA increases the reliability of information.

          In this embodiment, defect information contained in previously recorded

temporary defect information #0, #1, #2,..., and #i-1 is not included in the temporary defect information #i. That is, only information regarding a defect detected from a recording area during a corresponding recording operation #i is included in the temporary defect information #i. For instance, the temporary defect information #0

5 specifies a defect detected during a recording operation #0, and the temporary defect information #1 specifies only a defect detected during a recording operation #1.

Accordingly, it is possible to effectively use a recording area of the TDMA. In other words, the recording area of the lead-in area (or the lead-out area or the outer area) including the TDMA is very smaller than a data area where user data is recorded.

10 Nevertheless, if information regarding a defect detected whenever a recording operation is performed is recorded to include all of information regarding defects detected during previous recording operations, data may not be further recorded in the TDMA before the data area is full of data. For this reason, in this embodiment, temporary defect information includes only information regarding a defect detected during a related

15 recording operation. Instead, during disc finalization, all defect information included in the temporary defect information #0, #1, #2, ..., #i is read and written to the DMA.

In the case of a high-density disc with a recording capacity of several dozens of GBs, it is desirable that a cluster is allocated to an area in which temporary defect management information #i is recorded and four to eight clusters are allocated to an

20 area in which temporary defect information #i is recorded. This is because it is preferable to record new information in units of clusters to update information when a minimum physical unit of record is a cluster, although the amount of temporary defect information #i is just several KBs. A total amount of defects allowed in a disc is preferably about 5 percentage of the disc recording capacity. For instance, about four

25 to eight clusters are required to record temporary defect information #i, considering that information regarding a defect is about 8 bytes long and the size of a cluster is 64 KBs long.

The verify-after-write method can also be performed on temporary defect information #i and temporary defect management information #i. When a defect is

detected, information recorded in an area of a disc having a defect may be either recorded in a spare area using linear replacement, or recorded in an area adjacent to the TDMA using slipping replacement.

FIG. 3B illustrates a data structure of a disc with a TDMA and DMAs shown in

5 FIG. 3A. Referring to FIG. 3B, two DMAs, i.e., DMA #1 and DMA #2, are formed to increase the robustness of defect management information and defect information.

TDMA denotes a temporary defect management area; *Test* denotes an area in which recording conditions of data are measured; *Drive and Disc information* is an area in which information regarding a drive used during a recording and/or reproducing  
10 operation(s) and disc information are recorded; and *Buffer 1*, *Buffer 2*, and *Buffer 3* are buffers indicating borders of the respective areas.

FIG. 4 is a view for explaining a relationship between the temporary defect management area and the temporary finalized defect management area, according to the present invention.

15 Referring to FIG. 4, if temporary management information including temporary defect information and temporary defect management information is recorded predetermined times in the TDMA, the recorded temporary management information is collected and recorded as temporary finalized management information in the temporary finalized defect management area. That is, if temporary management  
20 information TDMA #1, #2, ..., #k are recorded k times in the temporary defect management area, the recorded temporary management information TDMA #1, #2, ..., #k are finalized and recorded as temporary finalized management information TFDMA #1 in the TDMA. If temporary management information TDMA #k+1, ..., #2k are again recorded k times in the TDMA, the recorded temporary management information TDMA  
25 #k+1, ..., #2k are collected, finalized, and then recorded as temporary finalized management information TFDMA #2 in the temporary finalized defect management area.

The temporary finalized management information TDMA #1 includes the temporary defect information of the temporary management information TDMA #1, #2,



..., #k\*n, and information regarding a location at which next temporary management information TDMA #k\*n+1 is to be recorded. Accordingly, the recording or reproducing apparatus reads temporary defect information contained in the temporary finalized management information finally in the temporary finalized management area even  
5 before finalizing, and reads the remaining temporary defect information from next temporary management information recorded in the temporary defect management area with reference to information regarding a location in which the next temporary management information contained in the finally recorded temporary finalized management information is to be recorded, thereby more quickly detecting defect  
10 information than when no temporary finalized management information is recorded.

FIGS. 5A and 5B illustrate a data structure of the temporary defect management area, according to an embodiment of the present invention;

FIG. 5A illustrates a data structure of temporary management information TDMA according to an embodiment of the present invention. Referring to FIG. 4A,  
15 corresponding temporary defect information and temporary defect management information are recorded as a pair of information in the TDMA. More specifically, temporary management information *TDMA #1*, *TDMA #2* are sequentially recorded starting from the start of the TDMA. A pair of corresponding temporary defect management *TDDS #1* and temporary defect information *TDFL #1* are included twice in  
20 the temporary management information *TDMA #1*. A pair of corresponding temporary defect management information *TDDS #2* and temporary defect information *TDFL #2* are included twice in temporary management information *TDMA #2*. A reason for recording the same information twice is to increase the reliability and robustness of the information. The location information of the corresponding temporary defect  
25 information *TDFL #1*, *#2*, .. is respectively recorded in the temporary defect management information TDMA #1, #2, ... Each temporary defect management information further specifies the location of temporary defect information recorded right before its corresponding temporary defect information. For instance, the temporary management information *TDMA #2* sequentially includes a pair of the temporary defect

information *TDFL #2* and temporary defect management information *TDDS #2*, and a copy of the temporary defect information *TDFL #2* and temporary defect management information *TDDS #2*. The temporary defect management information *TDDS #2* contains location information regarding the temporary defect information *TDFL #2* and a  
5 copy of temporary defect information *TDFL #1* recorded right before the temporary defect information *TDFL #2*. The copy of the temporary defect management information *TDDS #2* contains location information regarding its corresponding copy of the temporary defect information *TDFL #2*, and location information regarding the temporary defect information *TDFL #2*. As described above, if temporary defect  
10 management information further specifies the location of temporary defect information recorded right before corresponding temporary defect information, it is possible to more rapidly read all recorded temporary defect information than where temporary defect information is accumulatively recorded. The number of recording the temporary defect management information *TDDS #1, #2* and the temporary defect information *TDFL #1, #2* is not limited.

FIG. 5B illustrates a data structure of a TDMA according to another embodiment of the present invention.

Referring to FIG. 5B, compared to the TDMA of FIG. 5A, corresponding temporary defect information and temporary defect management information are  
20 recorded as pairs of information in the TDMA, but the sequence of recording the information is not the same. More specifically, temporary management information *TDMA #1, #2, ...* is sequentially recorded starting from the end of the TDMA. A pair of corresponding temporary defect management *TDDS #1* and temporary defect information *TDFL #1* are included twice in the temporary management information  
25 *TDMA #1*. A pair of corresponding temporary defect management information *TDDS #2* and temporary defect information *TDFL #2* are included twice in temporary management information *TDMA #2*, thereby increasing the reliability and robustness of the information. The temporary defect management information *TDDS #1, #2, ...* specifies the locations of their corresponding temporary defect information *TDFL #1, #2*,

..., respectively. Each temporary defect management information further specifies the location of the temporary defect information recorded right before its corresponding temporary defect information. For instance, the temporary management information TDMA #2 sequentially includes a pair of the temporary defect information TDFL #2 and the temporary defect management information TDDS #2, and a copy of the temporary defect information TDFL #2 and the temporary defect management information TDDS #2. Also, the temporary defect management information TDDS #2 contains location information regarding the temporary defect information TDFL #2 and a copy of the temporary defect information TDFL #1 recorded right before the temporary defect information TDFL #2. The copy of the temporary defect management information TDDS #2 contains location information regarding its corresponding copy of the temporary defect information TDFL #2, and the location information regarding temporary defect management information TDFL #2.

FIGS. 6A through 6D illustrate a data structure of a temporary finalized defect management area according to an embodiment of the present invention.

FIG. 6A illustrates an example of a data structure of a temporary finalized defect management area.

Referring to FIG. 6A, temporary finalized management information TFDMA #1, TFDMA #2, ..., TFDMA #n are sequentially recorded in the temporary finalized defect management area TFDMA, starting from the start of the temporary finalized defect management area. Corresponding temporary finalized defect management information TFDDS #n and temporary finalized defect information TFDFL #n are respectively recorded twice in an arbitrary temporary finalized management information TFDMA #n, thereby improving the reliability and robustness of information.

corresponding temporary finalized defect information TFDFL #n is recorded in the temporary finalized defect management information TFDDS #n. Furthermore, information indicating the location of final temporary defect information recorded in corresponding temporary finalized defect information TFDFL #n, that is, location information of temporary management information TDMA #k\*n+1 which will be next

recorded when temporary finalized defect management information TFDDS #n is recorded after temporary management information is recorded k times, is recorded in the temporary finalized defect management information TFDDS #n.

Meanwhile, the number of recording the temporary finalized defect management information *TFDDS #n* and the temporary finalized defect information *TFDFL #n* is not limited.

FIG. 6B illustrates an example of FIG. 6A.

Referring to FIG. 6B, if temporary finalized management information TFDMA #1, #2, ..., #n is respectively recorded whenever temporary management information TDMA is recorded k times, the recorded temporary defect information TDFL #1, #2, ..., #k\*n are all accumulated and recorded in the temporary finalized defect information TFDFL #n. Temporary finalized defect management information TFDDS #n includes a pointer indicating the location of the corresponding temporary finalized defect information TFDFL #n, and a pointer indicating the location of temporary management information TDMA #k\*n+1 which will be next recorded, wherein k is an integer equal to or greater than 2.

FIG. 6C illustrates another example of a data structure of the temporary defect management area.

Referring to FIG. 6C, information is recorded in the same way as described above with reference to FIG. 6A, but the recording positions of information are not the same. That is, temporary finalized management information TFDMA #1, TFDMA #2, ..., TFDMA #n are sequentially recorded in a temporary finalized defect management area, starting from the end of the temporary finalized defect management area.

Corresponding temporary finalized defect management information TFDDS #n and temporary finalized defect information TFDFL #n are respective recorded twice in an arbitrary temporary finalized management information TFDMA #n, thereby improving the reliability and robustness of information. The location information of the corresponding temporary finalized defect information TFDFL #n is recorded in the temporary finalized defect management information TFDDS #n. Furthermore,

information indicating the location of final temporary defect information recorded in corresponding temporary finalized defect information *TFDFL #n*, that is, location information of temporary management information *TDMA #k\*n+1* which will be next recorded when temporary finalized defect management information *TFDDS #n* is recorded after temporary management information is recorded *k* times, is recorded in the temporary finalized defect management information *TFDDS #n*, wherein *k* is an integer equal to or greater than 2.

Meanwhile, the number of recording the temporary finalized defect management information *TFDDS #n* and the temporary finalized defect information *TFDFL #n* is not limited.

FIG. 6D is an example of FIG. 6C.

Referring to FIG. 6D, if temporary finalized management information *TFDMA #1, #2, ..., #n* is respectively recorded whenever temporary management information *TDMA* is recorded *k* times, the recorded temporary defect information *TDFL #1, #2, ..., #k\*n* are all accumulated and recorded in the temporary finalized defect information *TFDFL #n*. Temporary finalized defect management information *TFDDS #n* includes a pointer indicating the location of the corresponding temporary finalized defect information *TFDFL #n*, and a pointer indicating the location of temporary management information *TDMA #k\*n+1* which will be next recorded, wherein *k* is an integer equal to or greater than 2.

FIG. 7A illustrates a data structure of temporary defect management information *TDDS #i*.

Referring to FIG. 7A, the temporary defect management information *TDDS #i* includes an identifier for the temporary defect management information *TDDS #i*, a pointer to the recording position of a copy of temporary defect information *TDFL #i-1* recorded right before corresponding temporary defect information *TDFL #i*, and a pointer to the recording position of the temporary defect information *TDFL #i*.

FIG. 7B illustrates a data structure of a copy of temporary defect management information *TDDS #i*.

Referring to FIG. 7B, the copy of temporary defect management information *TDDS #i* contains an identifier for the copy of the temporary defect management information *TDDS #i*, a pointer to the recording position of the temporary defect information *TDFL #i* recorded in the temporary defect management information *TDDS #i*,  
5 and a pointer to the recording position of a copy of the temporary defect information *TDFL #i*.

FIG. 8 illustrates a data structure of temporary defect information *TDFL #i*. Referring to FIG. 8, temporary defect information *TDFL #i* contains an identifier for the temporary defect information *TDFL #i*, and information regarding a defect detected  
10 during a corresponding recording operation *#i*. That is, information regarding defects detected during previous recording operations *#0, #1, ..., #i-1* is not included in the temporary defect information *TDFL #i*. Here, the information regarding a defect indicates the positions of the defect and its replacement and whether the defect occurs in a single defect block or continuous defect blocks. A detailed data structure of  
15 information regarding disc defects will be described later.

FIG. 9 is a reference diagram illustrating in detail recording of data in a user data area *A* and a spare area *B*, according to a preferred embodiment of the present invention.

Data can be processed in units of sectors or clusters. A sector denotes a  
20 minimum unit of data that can be managed in a file system of a computer or in an application. A cluster denotes a minimum unit of data that can be physically recorded on a disc at once. In general, one or more sectors constitute a cluster.

There are two types of sectors: a physical sector and a logical sector. The physical sector is an area on a disc where a sector of data is to be recorded. An  
25 address for detecting the physical sector is called a physical sector number (PSN). The logical sector is a unit in which data can be managed in a file system or an application. An address for detecting the logical sector is called a logical sector number (LSN). A disc recording/reading apparatus detects the recording position of data on a disc using a PSN. In a computer or an application relating to data, the entire data is managed in

units of LSNs and the position of data is detected using an LSN. LSNs and PSNs are mapped by a controller of the recording/reading apparatus, based on whether the disc contains a defect and an initial recording position of data.

Referring to FIG. 9, *A* denotes a user data area and *B* denotes a spare area in which PSNs are sequentially allocated to a plurality of sectors (not shown). In general, each LSN corresponds to at least one PSN. However, since LSNs are allocated to non-defective areas, including replacements recorded in the spare area, the correspondence between the PSNs and the LSNs is not maintained when a disc has a defective area, even if the size of a physical sector is the same as that of a logical sector.

In the user data area *A*, user data is recorded either in a continuous recording mode or a random recording mode. In the continuous recording mode, user data is recorded sequentially and continuously. In the random recording mode, user data is randomly recorded. In the data area *A*, sections ① through ⑦ denote predetermined units of data in which the verify-after-write method is performed. A recording apparatus records user data in section ①, returns to the start of section ①, and checks if the user data is appropriately recorded or a defect exists in section ①. If a defect is detected in a portion of section ①, the portion is designated as defect #1. The user data recorded in defect #1 is also recorded on a portion of the spare area *B*. Here, the portion of the spare area *B* in which data recorded in defect #1 is rewritten is called replacement #1. Next, the recording apparatus records user data in section ②, returns to the start of section ②, and checks whether the data is properly recorded or a defect exists in section ②. If a defect is detected in a portion of section ②, the portion is designated as defect #2. Likewise, replacement #2 corresponding to defect #2 is formed in the spare area *B*. Further, defect #3 and replacement #3 are designated in section ③ of the user data area *A* and the spare area *B*, respectively. In section ④, a defect does not occur and a defective area is not designated.

The recording apparatus records information regarding defect #1, #2, and #3

occurring in sections ① through ④ as temporary defect information *TDFL #1* in a TDMA, when recording operation #1 is expected to end, after the recording and verifying of data to section ④, i.e., when a user presses the eject button of a recording apparatus or recording of user data allocated in a recording operation is complete.

5 Also, management information for managing temporary defect information *TDFL #1* is recorded as temporary defect management information *TDDS #1* in the TDMA.

When recording operation #2 starts, data is recorded in sections ⑤ through ⑦ and defects #4 and #5 and replacements #4 and #5 are formed. If the second recording operation #2 is expected to end, the recording apparatus records information  
10 regarding defects #4 and #5 as temporary defect information *TDFL #2*. Likewise, defect management information for managing the *TDFL #2* is recorded as *TDDS #2* in the temporary defect management area.

FIG. 10 illustrates data structures of temporary defect information *TDFL #1* and #2 recorded as explained with respect to FIG. 9.

15 Referring to FIG. 10, the temporary defect information *TDFL #1* describes defects detected during a recording operation #1. That is, the temporary defect information *TDFL #1* contains information regarding defects #1, #2, and #3. The information regarding defect #1 indicates the position of an area in which defect #1 exists and the position of an area in which replacement #1 is recorded. The  
20 information regarding defect #2 indicates the position of an area in which defect #2 exists, and the position of an area in which replacement #2 is recorded. The information regarding defect #3 the position of an area in which defect #3 exists, and the position of an area in which replacement #3 is recorded.

Temporary defect information *TDFL #2* describes only defects detected during a  
25 recording operation #1. That is, the temporary defect information *TDFL #1* contains information regarding defects #4 and #5.

FIG. 11 illustrates a data structure of information regarding a defect #i according to a preferred embodiment of the present invention.

Referring to FIG. 11, the information regarding a defect #i describes a pointer to



the defect #i and a pointer to a corresponding replacement #i. Further, the information regarding the defect #i may further include state information that indicates whether the defect #i occurs in continuous defect blocks or a single defect block. The inclusion of the state information into the information regarding the defect #i is optional. If the defect #i occurs in the continuous defect blocks, the state information further represents whether the pointer for defect #i points to the start or end of the continuous defect blocks and whether the pointer for replacement #i points to the start or end of a replacement block that replaces defect #i. When the state information indicates the pointer for defect #i as the start of the continuous defect blocks and the pointer for replacement #i as the start of the replacement block, the pointer for defect #i represents a starting physical sector number of the continuous defect blocks and the pointer for replacement #i represent a starting physical sector number of replacement #i. In contrast, when the state information indicates the pointer for defect #i as the end of the continuous defect blocks and the pointer for replacement #i as the end of the replacement block, the pointer for defect #i represents an ending physical sector number of the continuous defect blocks and the pointer for replacement #i represent an ending physical sector number of replacement #i. The definition of at least two continuous defect blocks where defects exist using state information enables effectively recording of information and saves a space of recording, even if information regarding defects is not recorded in units of blocks. Here, the block denotes a logical record unit of data.

The pointer for defect #i specifies a starting and/or ending point(s) of defect #i. The pointer for defect #i may include a starting PSN of defect #i. The pointer for replacement #i specifies a starting and/or ending points of replacement #i. The pointer for replacement #i may also include a starting PSN of replacement #i.

Hereinafter, preferred embodiments of a disc defect management method according to the present invention using the recording unit 1 of FIG. 1 and the disc 100 according to the first embodiment of the present invention, will be described with reference to the accompanying drawings.

FIG. 12 is a flowchart illustrating a disc defect management method according to a first embodiment of the present invention.

Referring to FIG. 12, the recording apparatus sets  $n$  to 1 (operation 1201), and records only defect information for data recorded according to a  $n$ -th recording operation, as  $n$ -th temporary defect information, in a temporary defect management area, in order to manage disc defects (operation 1202). Also, management information for managing the  $n$ -th temporary defect information is recorded as the  $n$ -th defect management information in the temporary defect management area (operation 1203).

Before finalizing is performed (operation 1204), operations 1202 and 1203 are repeated while increasing  $n$  by 1 until  $n$  becomes a multiple of  $k$  (operation 1208). If  $n$  becomes a multiple of  $k$  (operation 1205), the recorded temporary defect information is all collected and recorded as a  $n/k$ -th temporary finalized defect information in the temporary finalized defect management area (operation 1206),  $n/k$ -th temporary finalized defect management information including information for managing the  $n/k$ -th temporary finalized defect information, and information indicating a location which the next temporary defect information (and/or temporary defect management information) will be recorded, is recorded in the temporary finalized defect management area (operation 1207), and the above operations are repeated while increasing  $n$  by 1 until  $n$  becomes a multiple of  $k$  before finalizing is again performed.

If finalizing is performed (operation 1204), the recorded temporary defect management information and temporary defect information are read from the temporary finalized defect management area and the temporary defect management area, and recorded in the defect management area (operation 1209). In more detail, temporary defect information included in temporary finalized management information finally recorded in the temporary finalized management area is all read, and the location of the remaining temporary defect information recorded in the temporary defect management area is detected from the temporary finalized management information, thereby reading the remaining temporary defect information. Thus, the recorded temporary defect management information and temporary defect information are simultaneously recorded

as final defect management information and final defect information in the defect management area. The final defect information and the final defect management information can be repeatedly recorded in order to improve the reliability of data recording. Also, if a defect is found in the final defect information and the final defect management information upon verification after recoding, all data recorded after a part in which the defect is found is neglected (the all data is designated to a defective area), and then the remaining final defect information and final defect management information are recorded after the defective area is designated.

FIG. 13 is a flowchart illustrating a disc defect management method according to a second embodiment of the present invention.

Referring to FIG. 13, the recording apparatus sets  $n$  to 1 (operation 1301), and records user data in a data area when verification is performed after recording (operation 1302). Then, data recorded in operation 1301 is verified and a part in which a defect is generated is detected (operation 1303). The controller 2 designates the part in which the defect is generated to a defective area, again records data recorded in the defective area in a spare area to generate a replacement area, generates pointer information indicating the part in which the defect is generated and the replacement area (operation 1304), and then stores the pointer information as temporary defect information in the memory 3 (operation 1305). Here, state information representing whether the defective area is a single defect block or successive defective blocks, is further generated, and the state information can be also stored as temporary defect information. Before the recording operation is expected to end (operation 1306), operations 1302 through 1305 are repeated.

If user data recording is complete according to a user's input or a recording operation and the recording operation is expected to end (operation 1306), the controller of the recording apparatus reads temporary defect information stored in the memory 3, records the temporary defect information as temporary defect information TDFL #1 in the temporary defect management area (operation 1307), and records temporary defect management information TDDS #1 as management information for

managing the TDFL #1, twice (operation 1308). Here, the number of data recording can vary. Operations 1302 through 1308 are repeated while increasing n by 1 (operation 1313) until finalizing is performed (operation 1309). Whenever operations 1302 through 1308 operate, indexes added to the TDFL and TDDS are increased by 1 (operation 1314). The temporary defect information TDFL #i records only information regarding a defect generated in the corresponding recording operation #i, and does not record information regarding a defect generated in the previous recording operations #1, #2, ..., #i-1.

If n becomes a multiple of k (operation 1310) before finalizing is performed (operation 1309), the recorded TDFL is collected, finalized, and recorded as temporary finalized defect information TFDFL #1 (operation 1311), and TFDDS #1 containing information for managing TFDFL #1 and information indicating a location in which the next temporary defect information TDFL (and/or temporary defect management information TDDS) is recorded, is recorded (operation 1312). Whenever n becomes a multiple of k (operation 1310) until finalizing is performed (operation 1309), operations 1311 and 1312 are repeated while increasing indexes added to the TFDFL and TFDDS by 1 (operation 1314).

If finalizing is performed (operation 1309), the recorded temporary defect information and the temporary defect management information are all read from the temporary defect management area and the temporary finalized defect management area, and simultaneously recorded as final defect information DFL and final defect management information DDS (operation 1315). The final defect information DFL and the final defect management information DDS can be repeatedly recorded several times in the defect management area, in order to improve the reliability of data detection.

#### [Effect of the Invention]

As described above, the present invention provides a disc defect management method that is applicable to write once discs. By forming a temporary defect management area and a temporary finalized defect management area in a lead-in area

and/or a lead-out area, recording defect information in such a manner that the defect information corresponds to a recording operation, finalizing defect information recorded in the temporary defect management area and recording the finalized defect information in the temporary finalized defect management area if a predetermined number of pieces  
5 of defect information is recorded in the temporary defect management area, and recording location information which next defect information will be recorded in the temporary finalized defect management area, defect information can be more rapidly read even before finalizing. Furthermore, by temporary all temporary defect information recorded in the temporary defect management area and the temporary  
10 finalized defect management area and simultaneously recording the all temporary defect information in a defect management area, when finalizing, it is possible to more effectively use the defect management area. Accordingly, in the case of a write once disc, by performing defect management while recording user data, it is possible to stably perform a backup operation without any interruption.

15

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What is claimed is:

1. A write once disc with at least one record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, the write once disc comprising:

5 a defect management area formed on at least one of the lead-in area and the lead-out area;

a temporary defect management area formed on at least one of the lead-in area and the lead-out area; and

10 a temporary finalized defect management area formed on at least one of the lead-in area and the lead-out area,

wherein the temporary defect management area is an area in which temporary defect information indicating only information regarding defects generated during the corresponding recording operation, and temporary defect management information indicating information for managing the temporary defect information are recorded,

15 the temporary finalized defect management area is an area in which temporary finalized defect management area including at least one part of the temporary defect information recorded in the temporary defect management area, and temporary finalized defect management information indicating information for managing the temporary finalized defect information are recorded, and

20 the defect management area is an area in which the temporary defect information and the temporary defect management information are respectively recorded as defect information and defect management information when finalizing.

2. A write once disc with a first record layer on which a lead-in area, a data area, and a lead-out area are sequentially arranged, and a second record layer on which an outer area, a data area, and a lead-out area are sequentially arranged, the write once disc comprising:

a defect management area formed on at least one of the lead-in area, the lead-out area, and the outer area;

a temporary defect management area formed on at least one of the lead-in area, the lead-out area, and the outer area; and

a temporary finalized defect management area formed on at least one of the lead-in area, the lead-out area, and the outer area,

5 wherein the temporary defect management area is an area in which temporary management information indicating only information regarding defects generated during the corresponding recording operation is recorded,

the temporary finalized defect management area is an area in which temporary finalized management area including at least one part of the temporary management  
10 information is recorded, and

the defect management area is an area in which the temporary management information recorded when finalizing and the defect information and the defect management information obtained on the basis of the temporary finalized management information are respectively recorded.

15

3. The write once disc of claim 1 or 2, wherein the temporary finalized management information is recorded whenever the temporary management information is recorded k times, wherein k is an integer equal to or greater than 2.

20

4. The write once disc of claim 3, wherein the temporary finalized management information is obtained on the basis of temporary management information recorded when a target recording time reaches, wherein k is an integer equal to or greater than 2.

25

5. The write once disc of claim 4, wherein the temporary finalized management information comprises all temporary defect information constructing the temporary management information recorded when the target recording time reaches.

6. The write once disc of claim 3, wherein a plurality of defect management

areas are provided.

7. The write once disc of claim 1 or 2, wherein the temporary management information includes the temporary defect informant and the temporary defect management information, and the temporary defect informant and the temporary defect management information are recorded as a pair of information to be adjacent to each other in the temporary defect management area.

8. The write once disc of claim 7, wherein the temporary defect information and temporary defect management information are recorded several times, and the temporary defect management information includes information regarding the location of corresponding temporary defect information.

9. The write once disc of claim 3, wherein the temporary defect information includes a pointer pointing out to the location of a defect and a pointer pointing out to the location of a replacement for the defect.

10. A method of managing disc defects, the method comprising:

(a) recording only information regarding a defect detected in data, which is recorded in a data area of a disc during a first recording operation, as first temporary defect information in a temporary defect management area;

(b) repeating (a) and (b) at least once while increasing indexes given to the recording operation and the temporary management information by 1;

(c) recording temporary management information obtained on the basis of the recorded temporary management information whenever the first temporary management information is recorded k times, in a temporary finalized defect management area;

(d) repeating (a) through (c) at least once; and

(e) reading and writing all of recorded temporary defect management information



and temporary defect information in a defect management area (k is an integer equal to or greater than 2).

11. The method of claim 10, wherein operation (e) is performed after data  
5 according to a final recording operation is recorded in the data area.

12. The method of claim 10, wherein the temporary defect management area is formed in at least one of a lead-in area and a lead-out area of the disc.

10 13. The method of claim 10, wherein the temporary finalized defect management area is formed in at least one of a lead-in area and a lead-out area of the disc.

14. The method of claim 10, wherein the defect management area is formed  
15 in at least one of a lead-in area and a lead-out area of the disc.

15. The method of claim 10, wherein the temporary management information includes temporary defect information and temporary defect management information, and operation (a) comprises sequentially recording the temporary defect information  
20 and the temporary defect management information as pairs of information to be adjacent to each other, starting from the start of the temporary defect management area.

16. The method of claim 15, wherein operation (a) comprises  
25 repeatedly recording the temporary defect information and the temporary defect management information several times, and recording location information of temporary defect information corresponding to each temporary defect management information and location information of temporary defect information recorded just before the temporary defect management information, in the temporary defect management

information.

17. The method of claim 10, wherein the temporary management information includes temporary defect information and temporary defect management information,  
5 and operation (a) comprises sequentially recording the temporary defect information and the temporary defect management information as pairs of information to be adjacent to each other, starting from the end of the temporary defect management area.

18. The method of claim 17, wherein operation (a) comprises repeatedly  
10 recording the temporary defect information and the temporary defect management information several times.

19. The method of claim 18, wherein operation (a) comprises repeatedly recording the temporary defect information and the temporary defect management  
15 information several times, and recording location information of temporary defect information corresponding to each temporary defect management information and location information of temporary defect information recorded just before the temporary defect management information, in the temporary defect management information.

20. The method of claim 10, wherein operation (a) comprises:  
(a1) recording data in a predetermined unit of data;  
(a2) verifying the recorded data to detect a part in which a defect is found;  
(a3) storing defective area information indicating the part in which the defect is found, and information indicating a substitution area for substituting for the part in which  
25 the defect is found, as temporary defect information, in a memory;  
(a4) repeating operation (a1) through (a3) at least one time;  
(a5) if the recording operation is terminated, reading the information stored in the memory and recording the read information as temporary defect information in the temporary defect management area; and

(a6) recording temporary defect management information for managing the temporary defect information.

21. A recording apparatus comprising:

5 a recording/reading unit that records data on or reads data from a disc; and  
a controller that controls the recording/reading unit to record information regarding a defect detected from data, which is recorded in a data area of the disc according to a recording operation, as first temporary defect information in a temporary defect management area, and to record temporary finalized management information  
10 obtained on the basis of the temporary defect management information recorded in the temporary defect management area whenever the temporary management information is recorded k times, in a temporary finalized defect management area, wherein k is an integer equal to or greater than 2.

15 22. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit in such a manner that the temporary defect information and the temporary defect management information constructing the temporary management information are recorded as pairs of information to be adjacent to each other.

20 23. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit so that location information of temporary defect information corresponding to the temporary management information and location information of temporary defect information recorded just before the corresponding temporary defect information are recorded.

25 24. The recording apparatus of claim 21, wherein the controller controls the recording/reading unit so that the recording/reading unit records the temporary management information in the temporary defect management area whenever a recording operation is performed, and records defect information and defect

management information obtained on the basis of the recorded temporary management information and temporary finalized management information, in a defect management area, when finalizing.

FIG. 1

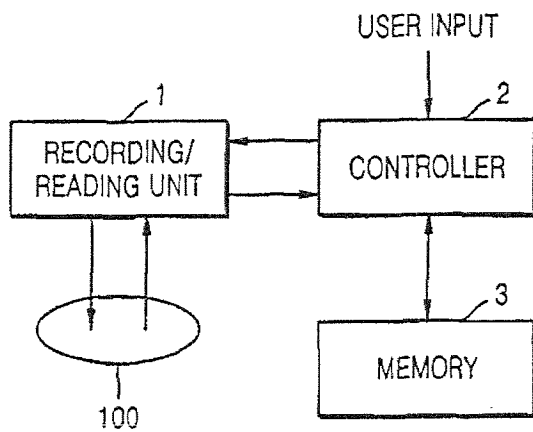
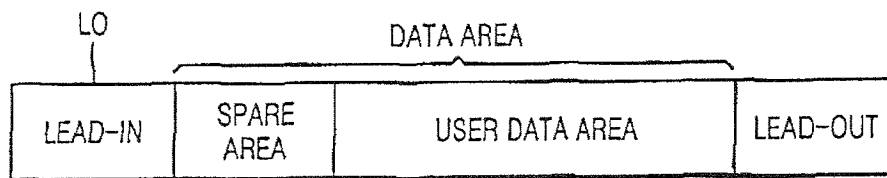
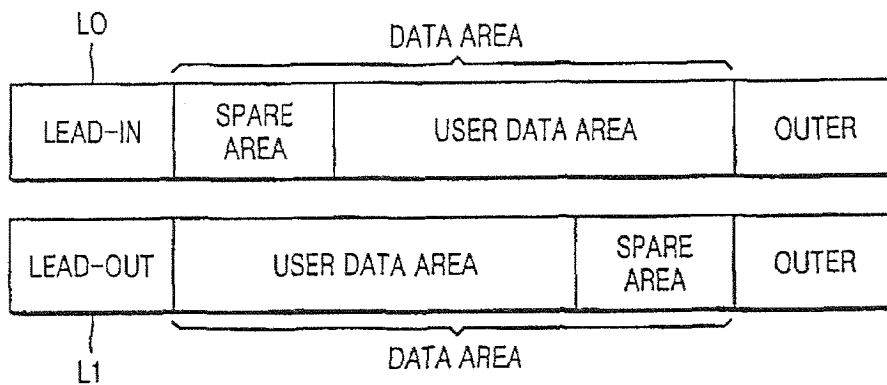


FIG. 2



(a)



(b)

FIG. 3A

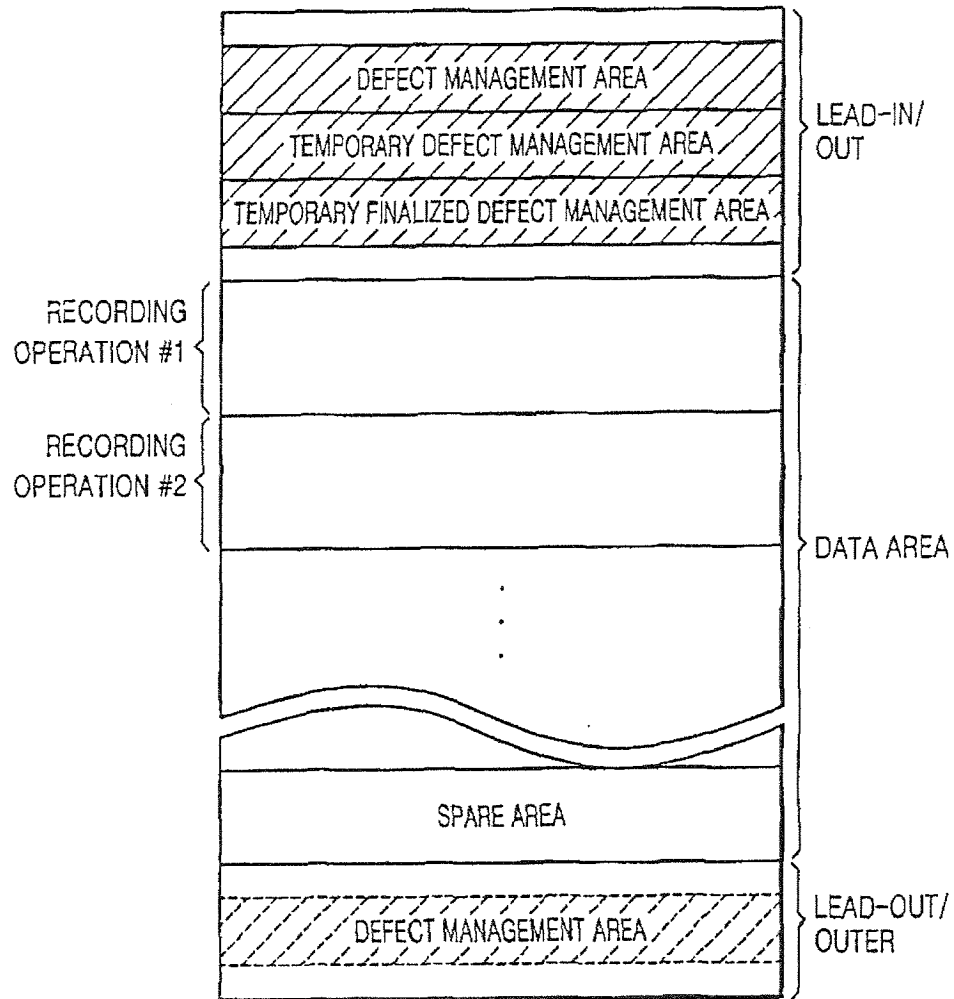


FIG. 3B

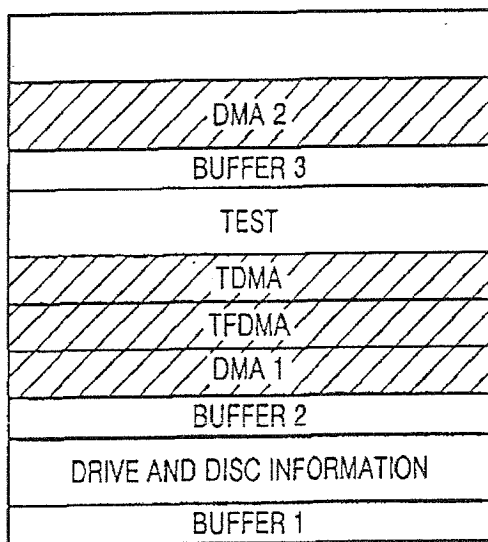


FIG. 4

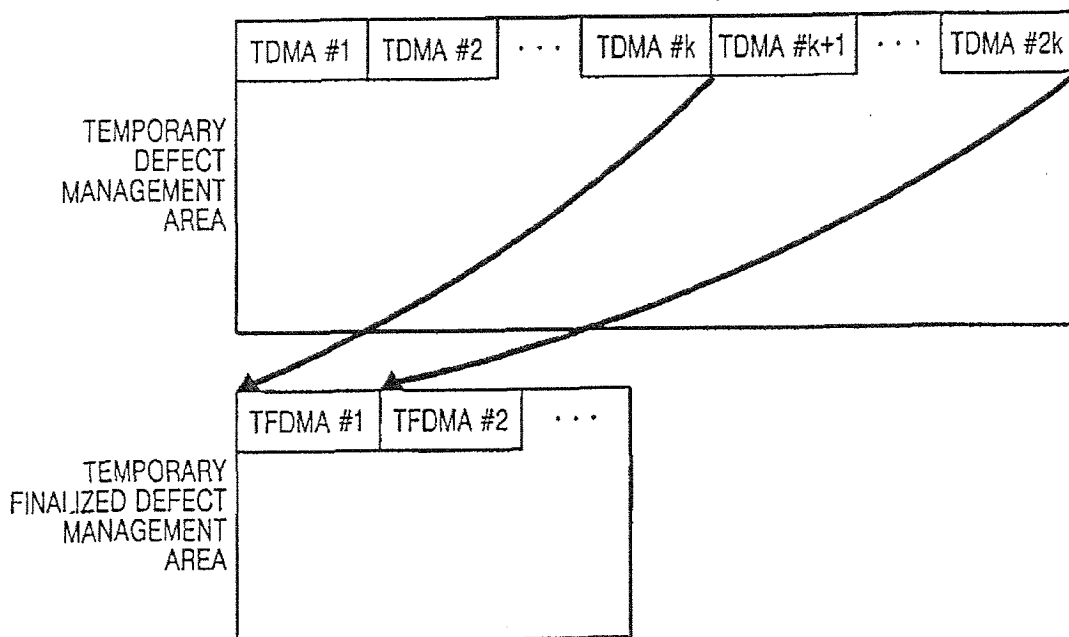


FIG. 5A

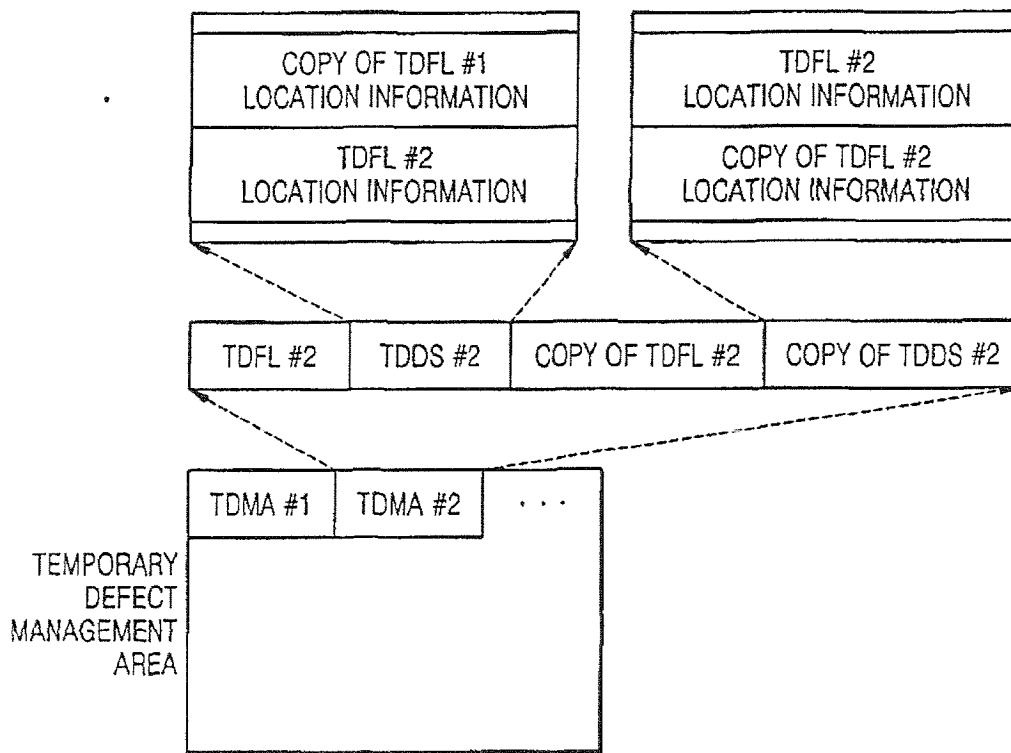




FIG. 5B

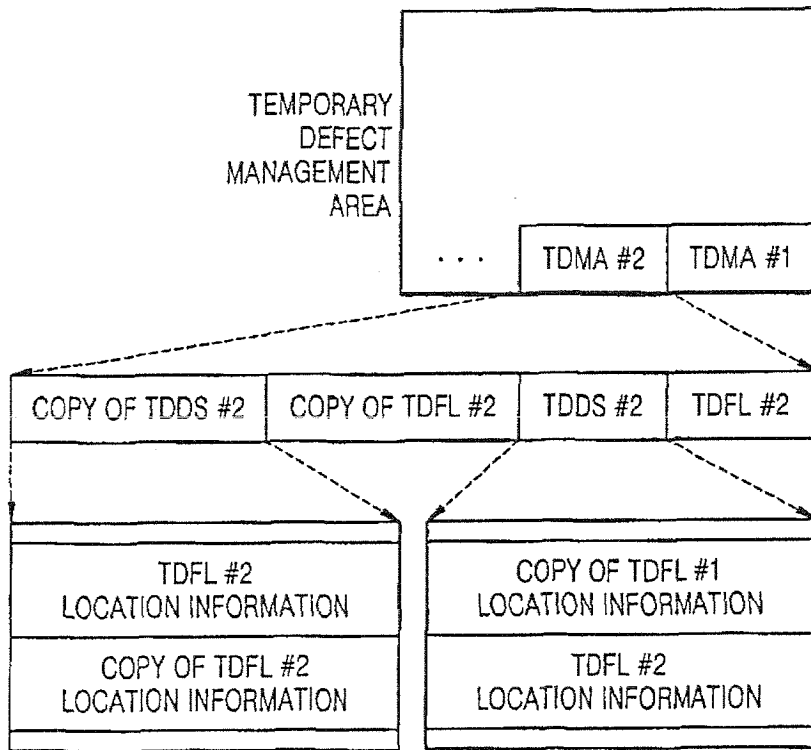


FIG. 6A

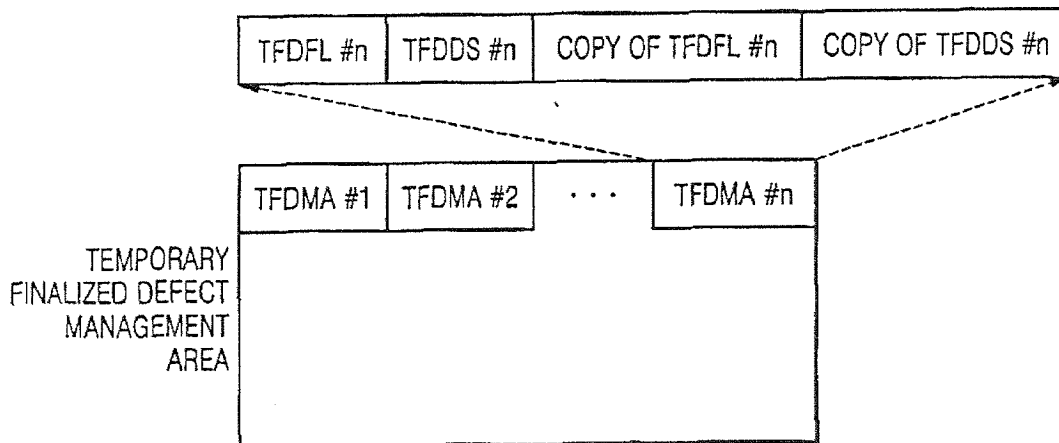


FIG. 6B

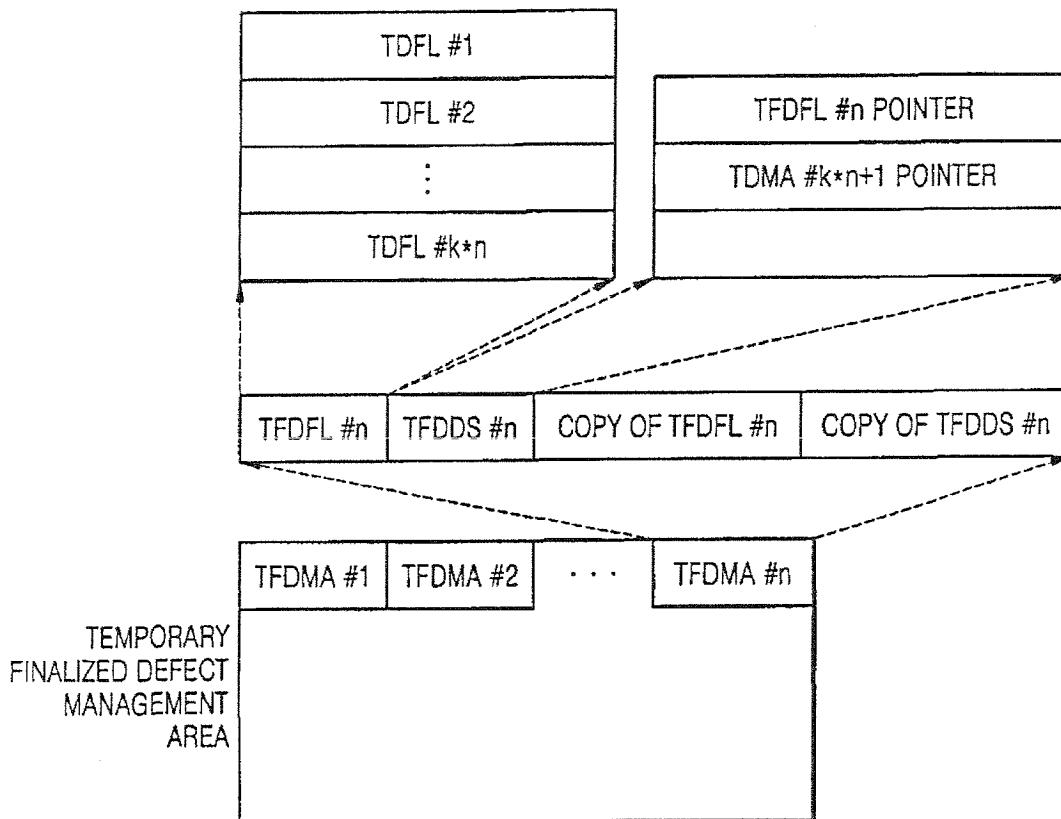


FIG. 6C

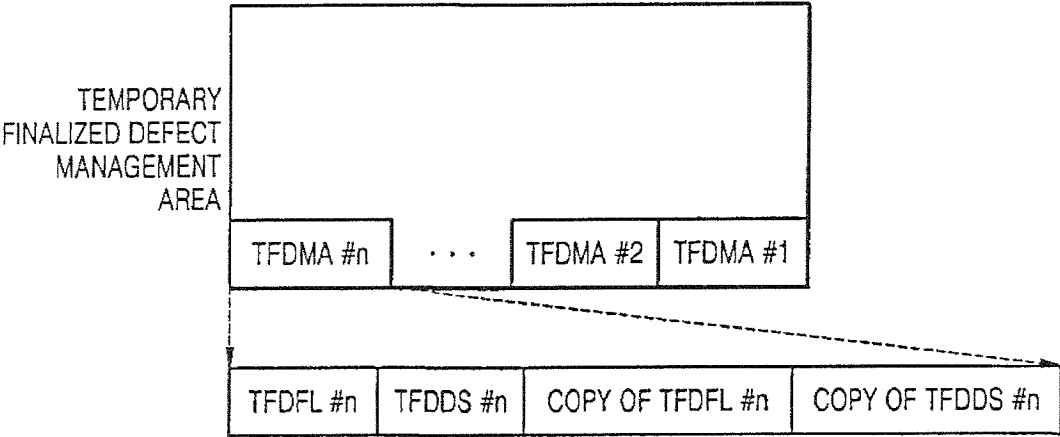


FIG. 6D

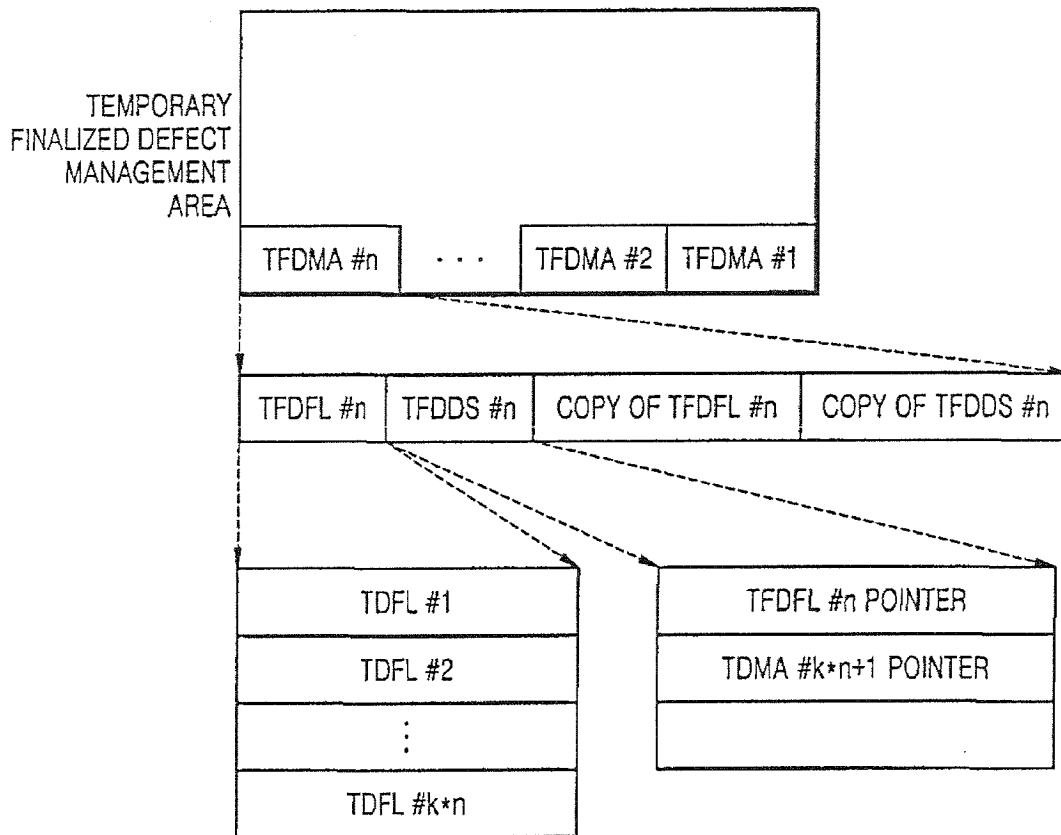


FIG. 7A

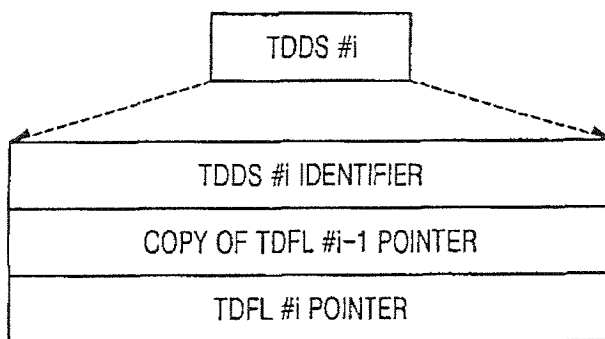


FIG. 7B

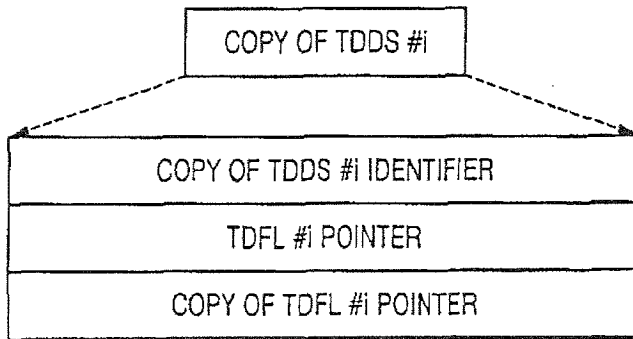


FIG. 8

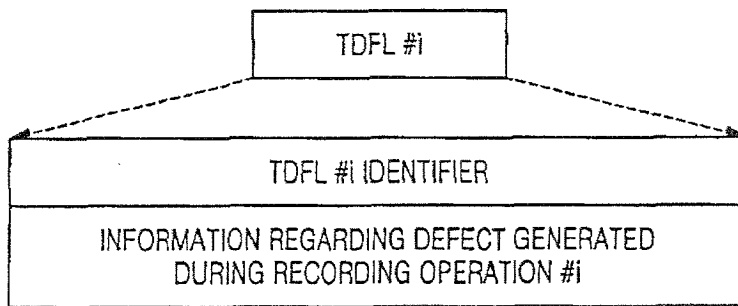


FIG. 9

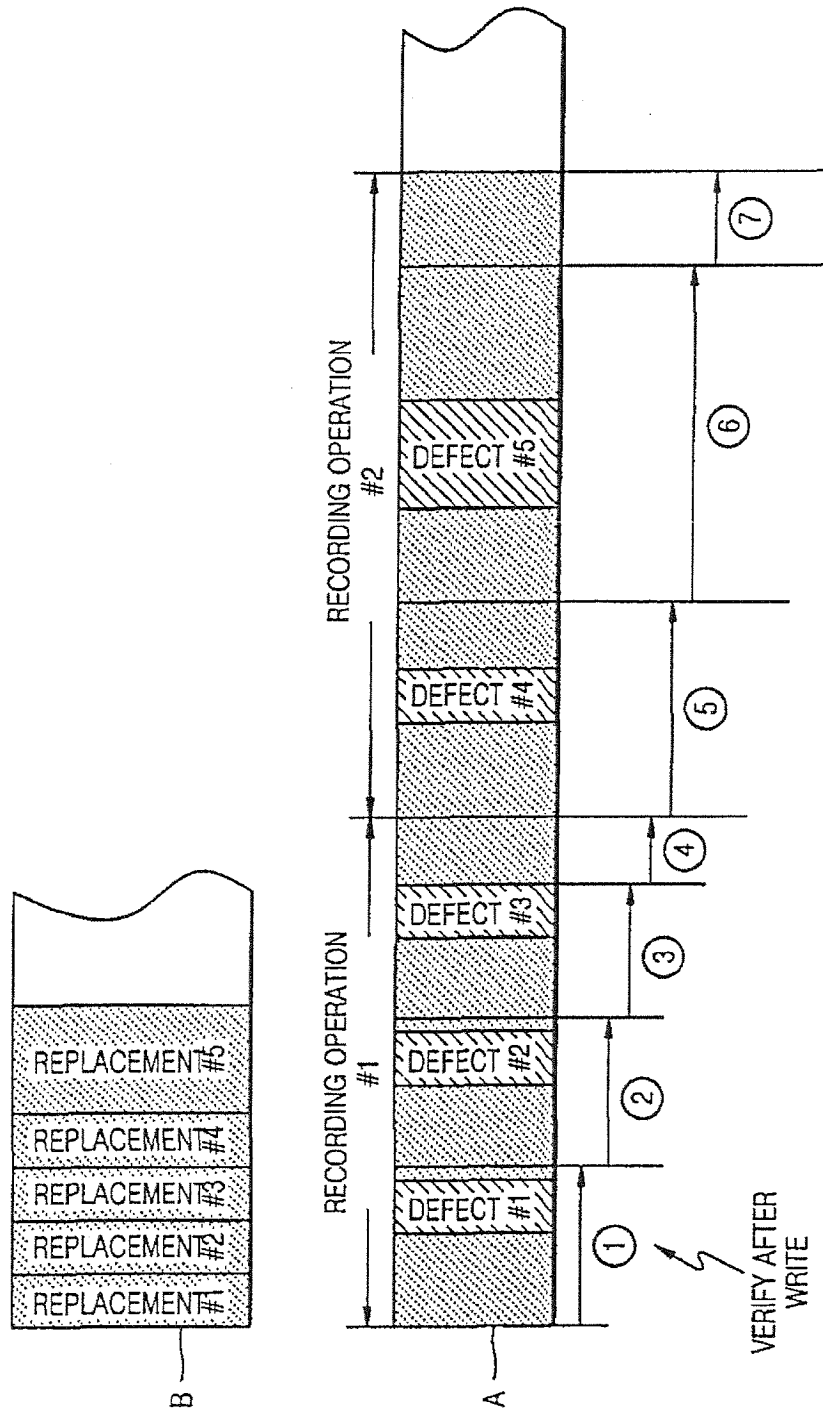
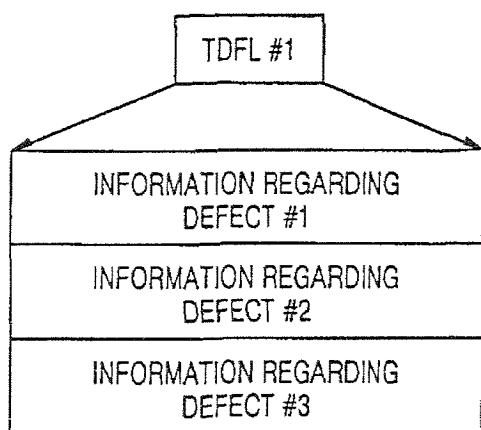
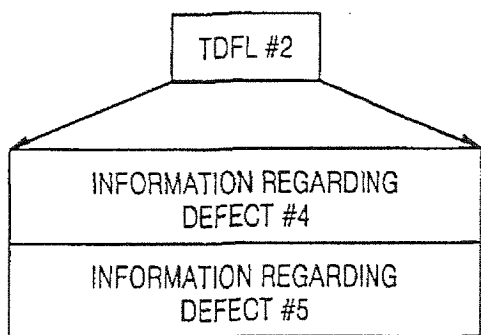


FIG. 10



(a)



(b)

FIG. 11

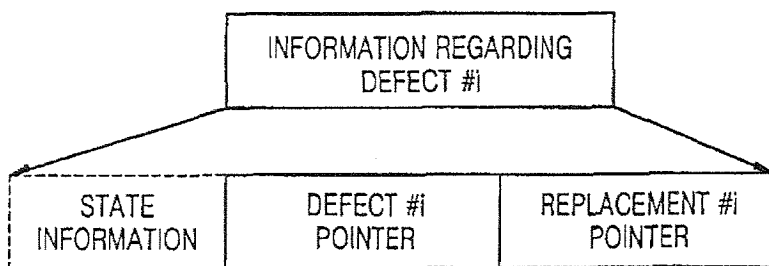


FIG. 12

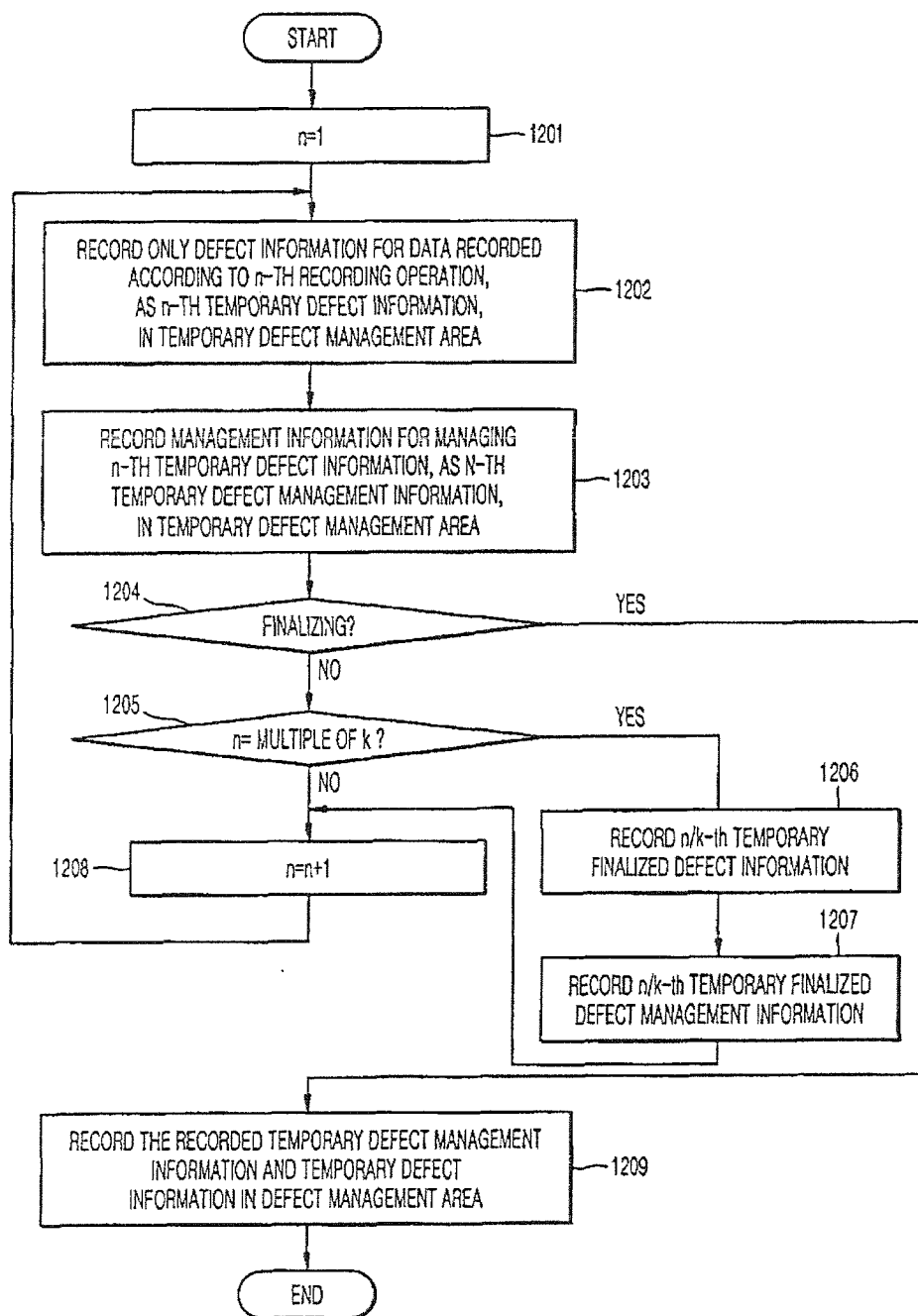




FIG. 13

